

Heights of rivers above zeros of gauges—Continued.

Stations.	Distance to mouth of river.	Danger line on gauge.	Highest water.		Lowest water.		Mean stage.	Monthly range.
			Height.	Date.	Height.	Date.		
<i>Clinch River.</i>	<i>Miles.</i>	<i>Feet.</i>	<i>Feet.</i>		<i>Feet.</i>		<i>Feet.</i>	<i>Feet.</i>
Speers Ferry, Va.	156	20	5.6	1	0.4	30	1.7	5.2
Clinton, Tenn.	46	25	16.0	1	4.8	30	8.8	11.2
<i>Wabash River.</i>								
Mount Carmel, Ill.	50	15	26.6	1	6.4	24	13.6	20.2
<i>Red River.</i>								
Arthur City, Tex.	688	27	16.1	1	3.3	{ 16.17, } 19, 20	6.1	12.8
Fulton, Ark.	565	28	22.9	1	5.0	22	11.2	17.9
Shreveport, La.	449	29	13.1	7	5.4	26	9.3	7.7
Alexandria, La.	139	33	15.1	8, 9	7.8	30	1.2	7.3
<i>Atchafalaya Bayou.</i>								
Melville, La.	100*	31	38.9	29, 30	20.7	1	32.2	4.2
<i>Ouachita River.</i>								
Camden, Ark.	340	39	18.0	1	5.9	22	9.6	12.1
Monroe, La.	100	40	19.8	30	13.5	18	16.5	6.3
<i>Yazoo River.</i>								
Yazoo City, Miss.	80	25	24.4	26-28	14.9	1	20.9	9.5
<i>Chattahoochee River.</i>								
Columbus, Ga.	140	20	13.0	6	1.7	19	4.4	11.3
<i>Flint River.</i>								
Albany, Ga.	80	20	7.0	10	1.2	1, 5	3.2	5.8
<i>Cape Fear River.</i>								
Fayetteville, N. C.	100	38	21.5	7	3.9	23	8.7	17.6
<i>Columbia River.</i>								
Umatilla, Oreg.	270	25	12.5	30	0.0	1	7.3	12.5
The Dalles, Oreg.	166	40	21.3	29, 30	5.3	1, 2	12.1	16.0
<i>Willamette River.</i>								
Albany, Oreg.	99	20	5.5	11, 16	3.8	2, 6	4.6	1.7
Portland, Oreg.	10	15	11.3	30	2.5	3	6.9	8.8
<i>Edisto River.</i>								
Edisto, S. C.	75	6	4.8	29, 30	2.6	1	3.8	2.3
<i>James River.</i>								
Lynchburg, Va.	257	18	5.4	1	1.3	30	2.8	4.1
Richmond, Va.	110	12	4.5	1	0.7	23	1.9	3.8
<i>Alabama River.</i>								
Montgomery, Ala.	265	35	20.2	7, 8	3.7	19, 20	9.8	16.5
Selma, Ala.	212	35	23.0	8, 9	4.7	21	11.9	18.3
<i>Coosa River.</i>								
Rome, Ga.	225	30	17.2	6	3.0	17-19, 23	5.6	14.2
Gadsden, Ala.	144	18	15.8	7, 8	3.3	18	7.6	13.5

Heights of rivers above zeros of gauges—Continued.

Stations.	Distance to mouth of river.	Danger line on gauge.	Highest water.		Lowest water.		Mean stage.	Monthly range.
			Height.	Date.	Height.	Date.		
<i>Tombigbee River.</i>	<i>Miles.</i>	<i>Feet.</i>	<i>Feet.</i>		<i>Feet.</i>		<i>Feet.</i>	<i>Feet.</i>
Columbus, Miss.	235	33	12.3	24	0.6	18	5.9	11.7
Demopolis, Ala.	155	35	32.9	7	9.3	20	23.9	23.6
<i>Black Warrior River.</i>								
Tuscaloosa, Ala.	90	38	38.7	6	8.1	19	20.8	30.6
<i>Pedee River.</i>								
Cheraw, S. C.	145	27	22.1	1	1.7	23	5.7	20.4
<i>Black River.</i>								
Kingstree, S. C.	60	12	5.1	15-18	3.1	4	4.2	2.0
<i>Lumber River.</i>								
Fairbluff, N. C.	10	6	3.9	30	1.1	1	2.8	2.8
<i>Lynch Creek.</i>								
Effingham, S. C.	35	12	9.0	30	3.6	2	5.5	5.4
<i>Polonnac River.</i>								
Harpers Ferry, W. Va. ...	170	16	8.9	17	2.9	{ 12-15, } { 26-28 }	3.9	6.0
<i>Roanoke River.</i>								
Clarksville, Va.	155	12	2.2	27	0.6	21, 22	1.2	1.6
<i>Sacramento River.</i>								
Redbluff, Cal.	241	23	1.2	7-25	1.0	1-6	1.1	0.2
Sacramento, Cal.	70	25	14.3	16-19, 27	12.5	1, 6	13.5	1.8
<i>Santee River.</i>								
St. Stephens, S. C.	50	12	8.2	15, 16	1.7	1	6.6	6.5
<i>Congaree River.</i>								
Columbia, S. C.	37	15	5.6	6	1.3	21-23	2.5	4.3
<i>Waterlee River.</i>								
Camden, S. C.	45	24	22.0	1	3.5	23	7.7	18.5
<i>Savannah River.</i>								
Augusta, Ga.	130	32	18.0	7	6.8	23	10.0	11.2
<i>Susquehanna River.</i>								
Wilkesbarre, Pa.	178	14	13.5	26	1.0	18, 22, 23	4.2	12.5
Harrisburg, Pa.	70	17	10.3	27	3.0	24	5.0	7.3
<i>Juniata River.</i>								
Huntingdon, Pa.	80	24	5.5	1	3.9	12-23	4.2	1.6
<i>W. Br. of Susquehanna.</i>								
Williamsport, Pa.	35	20	8.7	26	2.7	14, 15	4.5	6.0
<i>Waccamaw River.</i>								
Conway, S. C.	40	7	2.9	9	1.7	4, 20, 26	2.2	1.2

*Distance to Gulf of Mexico.

SPECIAL CONTRIBUTIONS.

A VISIT TO THE HIGHEST METEOROLOGICAL STATION IN THE WORLD.

By ROBERT DEC. WARD, Instructor in Climatology, Harvard University.
(Dated May 21, 1898.)

The highest meteorological station in the world is situated at an altitude of 19,200 feet on the summit of El Misti, a quiescent volcano near the city of Arequipa, Peru. This is one of a series of eight meteorological stations operated, in connection with the Harvard College Observatory, at Arequipa. The names and altitudes of the several stations are as follows: Mejia, 55 feet; La Joya, 4,141; Arequipa, 8,050; Pampa de los Huesos, 13,400; Misti, base, 15,700; Misti, summit, 19,200; Cuzco, 11,378; Echarati, 3,300. These places are roughly in a south-north line, and extend from the seacoast across both ranges of the Cordillera and down to Echarati, lying in a valley at the head of the Amazon River system.

The establishment of an astronomical and meteorological observatory at Arequipa, and of the seven other meteorological stations which are now operated in connection with it, was the result of a bequest left to the Harvard College Observatory in 1887 by the will of Mr. Uriah A. Boyden. The terms of the will were that the money should be used in establishing an observatory "at such an elevation as to be free, so far as practicable, from the impediments to accurate observation which occur in the observatories now existing, owing to atmospheric influences." Owing to the remarkable clearness and steadiness of the air at Arequipa it was decided, after a careful study of the meteorological conditions in other places, that the permanent observatory should be located here, and the buildings were erected in 1891. Arequipa is about 80 miles from the Pacific Ocean, in latitude 16° 22' 28" S., longitude 4° 46' 12", and about in the middle of the long

desert belt which stretches along the west coast of South America from latitude 4° to 30° S.

The small snowfall and comparatively high temperatures on the mountains of Peru offer exceptional opportunities for the establishment of meteorological stations at great altitudes, and since 1892 Harvard University has had the credit of maintaining in Peru the highest meteorological station in the world. In that year a station with ordinary and self-recording meteorological instruments was placed, by Prof. Wm. H. Pickering, at an elevation of 16,650 feet on Charcani, an extinct volcano 20,000 feet high, situated 12 miles north of Arequipa. The exposure of the instruments, however, was not favorable, owing to the fact that the station was in a somewhat sheltered position on the flank of the mountain, and in October, 1893, Prof. Solon I. Bailey, then in charge of the Arequipa Observatory, succeeded in establishing a new station on the summit of the Misti. This station is about 3,500 feet higher than the one on Mont Blanc, and is therefore the highest meteorological station in the world. The shape of the Misti is that of an almost perfect, although more or less truncated, cone, and the conditions of exposure of the instruments are as nearly perfect as it is possible to obtain on a mountain.

The instruments now in use on the summit are dry and wet bulb and maximum and minimum thermometers, rain-gauge, Richard barograph, thermograph, and hygrograph. There is also a meteorograph, constructed by Fergusson, of Blue Hill Observatory, especially for this station, and designed to record temperature, pressure, humidity, and wind direction and velocity, and to run three months without re-winding. This meteorograph has not yet given quite as complete records as it was originally hoped would be obtained

from it. Since its establishment the Misti station has been regularly visited by the observers from Arequipa, at first, and for many months, once in ten days, and since then about once a month. On these visits the clocks of the self-recording instruments are rewound, the record sheets changed, and check readings of all the instruments are made. The trip to the summit is by no means an easy one, and the altitude of the Misti is so great that almost everyone going up suffers from *soroche*, or mountain sickness. Although it has thus far been impossible, in view of the great altitude and the distance of the Misti station, to secure complete and continuous records from it, still the broken records which have been obtained are so interesting that this, to a considerable extent, makes up for their fragmental character.

The writer visited the Misti station twice during a recent stay of three months in Arequipa, and he has thought that it might interest the readers of the MONTHLY WEATHER REVIEW to know something of the physiological effects of the high altitude which these trips produced in his own case.

The trip from the observatory at Arequipa to the top of the Misti and back occupies two days, and is accomplished entirely on mule-back. The start from the observatory is made at 6 or 7 o'clock in the morning, each member of the party, including the guide, riding a mule, and one or two pack-mules being taken along to carry fodder for the use of the animals on the way, for the road is over barren, sandy deserts where nothing grows. Toward noon of the first day a stop is made to water the animals at a small spring—a great rarity in these dry regions—and at which many trains of pack-mules and llamas, winding their way across the pampa toward Arequipa, stop for water. About 3 or 4 in the afternoon a short stop is made on the Pampa de los Huesos, where the instrument shelter is visited, the clocks are rewound, the sheets changed, and check readings of the instruments made. The latter are wet and dry bulb thermometers and Richard barograph and thermograph. The Huesos station is on a pampa composed of volcanic sand and ashes, lying at the base of the Misti. This pampa is almost completely barren, and as there is no possibility of securing an observer here, readings of the instruments are made whenever a trip is made to the summit of the Misti.

The night is spent in a hut at the base of the mountain, at an altitude of 15,700 feet above sea level. Here is the next station, known as the "Mont Blanc" station, because its altitude and that of the summit of Mont Blanc are almost exactly the same. The "M. B." shelter, as it is called for brevity, is at a distance of about 200 feet from the hut. The instruments are wet and dry bulb and maximum and minimum thermometers, thermograph, and barograph, and this station is visited, as is that on the Pampa de los Huesos, when an expedition is made to the summit. The ascent from the hut to the summit occupies four or five hours, the descent to the hut about an hour and a half, and the ride back to Arequipa five hours more. It is, of course, an extremely fortunate circumstance that no physical exertion need be made in the ascent, for if persons unaccustomed to climbing at high altitudes were obliged to go on foot up the mountain, they would doubtless suffer severely from mountain sickness, for it is well known that exercise always increases the disagreeable symptoms of this malady. The mules that make the ascent all suffer more or less from shortness of breath, and near the summit they refuse to move more than 20 feet or so without stopping to get their breath. As a rule, however, they stand the strain remarkably well, and have, on several occasions when grass was taken to the summit, eaten at the altitude of 19,200 feet with the greatest apparent relish. Some of the mules belonging to the observatory have made the trip to the summit more than fifty times.

The writer's first ascent was made on October 7 last, and

was his first experience at a greater altitude than 9,000 feet. At the height of 13,400 feet, where it was necessary to walk about 300 feet, slightly up hill, to visit the instrument shelter, he was obliged to walk slowly, and even then got quite out of breath; but no considerable effects of the altitude were noticed until after the arrival at the "M. B." hut, at the altitude of 15,700 feet. Here the slight exertion of dismounting from the mule and walking into the hut brought on a violent headache, and the feeling of exhaustion was so great that any exercise, even of the most trifling character, seemed impossible. The writer was obliged to sit down at once, and could scarcely exert himself sufficiently to unpack the lunch basket, in order to take out the supplies for supper. A feeling of nausea, usually the first, as it is also the most common, symptom of mountain sickness, came on very soon, and the mere thought of eating was distasteful. However, after some delay, and by the use of considerable will power, a cup of hot milk and two soft-boiled eggs were disposed of, but it was found impossible to eat anything more. The night was passed in tolerable comfort, although the cold was so great that it was necessary to sleep with all one's clothing on, in a double set of winter underwear, ulster, and felt boots, and wrapped up in a sheepskin sleeping bag. Headache, a feeling of nausea, and quickened respiration were the only unpleasant symptoms noted during the night.

The following morning the headache was much lessened, but the feeling of exhaustion and nausea continued. The only food that could be taken was hot milk and an egg. The ride to the summit was accomplished without the appearance of any further unpleasant symptoms, but on the summit itself the feeling of complete exhaustion and of weakness was so great that for an hour and a half the slightest exertion was out of the question, and the writer was obliged to lie stretched out flat on the ground. There was some tendency to faintness during this time, and the headache and nausea continued. In a little less than two hours it was found possible, with great exertion, to change the sheets of the self-recording instruments, which were taken from and returned to the shelter by the guide, the writer remaining seated on the ground during the operation, as he found it impossible to lift the large-sized barograph, weighing perhaps 10 pounds, up into the shelter. When the time came for the descent, after two hours and a half spent on the summit, it was found necessary to have assistance in mounting the mule. At the hut, which was reached in two hours, the instrument shelter, placed about 300 feet from the hut, and about 75 feet higher up the mountain, had to be visited; and on this short walk two stops in order to take breath were necessary, and anything but a very slow walk was out of the question. The change to a lower altitude was, however, noticeable in a decrease in the feeling of exhaustion, but the headache and nausea continued for some two hours more, on the return ride to Arequipa. Although provided on this trip, with clinical thermometers and with a sphygmograph, the writer felt so miserably that he made very little use of these instruments. His temperature at 5:30 p. m., October 5, twelve hours before leaving Arequipa, was 98.4°, his respiration 24, and pulse 90; on the summit his temperature was 96.4°, respiration 34, and pulse 110; and twelve hours after arriving at Arequipa, at 10:30 a. m., October 8, the figures were 98.0°, 24, and 85 respectively. A rather unsatisfactory sphygmograph curve was obtained on the summit.

The second expedition to the Misti was made on November 9, and on this trip the writer suffered much less from mountain sickness than on the first. He was able, immediately after reaching the hut, at 15,700 feet, to walk to the instrument shelter, although two stops on the way were necessary, as before. An hour after taking this exercise the pulse was 128, the temperature 97.0°, and the respiration 30; the cor-

responding figures twelve hours before leaving Arequipa being 91, 98.6°, and 20. On this trip there was much less exhaustion than on the previous one; in fact, all the symptoms of mountain sickness were less marked. It was possible to walk in the hut without great exertion; there was much less feeling of nausea, and considerable appetite. The night was passed comfortably, except for the cold, which was very disagreeable. Supper and breakfast consisted of hot beef tea and milk biscuits. In the morning, immediately after waking, the temperature of the body was 96.2°, pulse 112, and respiration 30. On the summit the writer felt fairly well when lying down, but the exertion of walking even a few steps brought on a feeling of exhaustion and nausea, and increased his headache. Otherwise, he felt well, and even had considerable appetite, although it would probably have been impossible to eat much, even had there been any food at hand. Twenty minutes after reaching the summit the temperature was 97.2°, pulse 120, and respiration 32. In an hour and a half the respiration was 35, the pulse and temperature remaining the same. In two hours the temperature was 96.8°, the pulse 112, and respiration 34. Three fairly good sphygmograph curves were obtained on the summit, not without considerable difficulty, however. These curves, so far as the writer knows, are with one exception the only ones ever secured at so great an altitude as 19,200 feet. In counting the pulse on the summit it was quite unnecessary to place the finger on the wrist, as the heart beats could plainly be heard. The descent was begun two hours and a half after reaching the top. At the hut, after again walking to and from the shelter, the pulse was 130, but the respiration had decreased to 30. One hour after arrival at the observatory at Arequipa the temperature was 98.2°, pulse 116, and respiration 22, and twelve hours after arrival the pulse had fallen to 82, about the writer's normal at the observatory, and respiration to 22, the normal being 20.

While the ascent of the Misti is a very easy one, and is not for a moment to be compared with the difficult climb up such mountains as Aconcagua or Mont Blanc, the altitude is so great that a study of the physiological effects it produces is interesting. The writer fared very well, better, in fact, than most of those who have made the ascent. One of the former assistants at the observatory made the trip more than fifty times and never experienced any discomfort, and one gentleman was so well on the summit that he was able to smoke there. These, however, are the exceptions. Almost everyone has headache, nausea, and a feeling of intense weakness, and many are subject to faintness. The experience of the native guides, who are of mixed Spanish and Indian blood, is very striking in contrast to that of foreigners. These natives are usually able to walk all the way to the summit from the hut without any difficulty, and feel as well on the top as they do at the base.

SEISMIC AND OCEANIC NOISES.¹

By SAMUEL W. KAIN and others.

(A) Mr. Samuel W. Kain, in his letter of April 27, 1898, says:

It gives me much pleasure to send you by this mail a copy of Professor Ganong's article. I am also sending you two short notes from lighthouse keepers at the mouth of the Bay of Fundy. Mr. McLaughlin is

¹The Editor is indebted to the kindness of Samuel W. Kain, Librarian of the Natural History Society, St. John, N. B., for these valuable contributions to the study of certain remarkable sounds that have been observed in many parts of the world at sea and near the coasts. References to these noises have frequently been made in *Nature* and other European journals, as also in the *MONTHLY WEATHER REVIEW* during 1896 and 1897. They are known as "mist puffers" off the coast of Holland and as "barisal guns" off the mouth of the Ganges. Mr. Kain's contributions establish the fact of their frequency in the Bay of Fundy.

at the southern end of Grand Manan; Mr. Suthern is on Brier Island, on the Nova Scotian shore.

I wrote to these men in order to get some more information about this phenomenon. I have also personally questioned masters of fishing schooners, all of whom are familiar with these sounds, and among whom they are known by the somewhat vulgar but very expressive name of "sea farts." I am sending you these papers because I think these sounds very similar to those discussed in Europe about two years ago by Van den Broeck, Darwin, and others. A reference to them in the *REVIEW* may elicit more information than we now have.

(B) Walter B. McLaughlin, of Grand Manan, on remarkable sounds like gun reports, etc. (read March 1, 1898, before the Natural History Society of New Brunswick, and now quoted from the *St. Croix Courier*):

I beg to say that my attention was first called to these sounds in August, 1838. I was then a boy nine years old. I was with my brother and a fine young sailor, by the name of McCraw, of Lower Grandville, N. S. We were hooking mackerel, and I had just caught my first mackerel when "boom" went this heavy sound and away went our fine school of fish. McCraw said, "There she goes." I inquired the cause of these sounds so frequently made and the sailor's answer was: "We don't know, we hear them, but we can't explain them."

I have no doubt that many sounds heard by people on the main land are actually reports of Indians' guns in porpoise hunting, or the reports of our signal guns on those outer stations, but a practised man will not be deceived. I have noticed these sounds for fifty-nine years. I long since satisfied myself that these sounds are subterranean. I have heard them under the sea, under Gannet Rock, under the land (in South Lubec), and under Grand Manan in two different places; and, strange to say, we have had two splendid shots under this station lately, one on the evening of January 28 and the second on February 14, 1897. When they take place under Gannet Rock and under the land they have the heavy rattle of a 24-pounder cannon, exploded 40 feet from the buildings; but when they happen under the sea they have a dull harmless "boom," as such a gun would sound if fired 50 or more fathoms under the sea.

We used to hear those dull sounds frequently between the Wood Islands and Gannet Rock. They would often sound like the rush of a heavy ground swell into a subterranean cave. We always noticed them on fine calm days. I think this was because there was no wind or other noise to drown them. The first one of those sounds I heard under Gannet Rock was about fifty years ago, one clear, dark night, about 2 o'clock, a. m., in my watch. I was reading and was deeply interested, when bang went the shock of what seemed to be like a 24-pounder cannon. It brought down the soot from a heavy, boiler iron, extension pipe on the chimney top into an open fireplace. I, of course, went outside to investigate and found a clear, dark night with few clouds and light winds. It was, I think, in October.

My next experience of one of those sharp shocks was in the month of June, 1856, at South Lubec, West Quoddy Bay. I was at a Dr. William Small's, and was having a game at cards with the doctor about 2 o'clock in the morning, when bang went one of those subterranean guns, which nearly upset our lamp. I exclaimed, "An earthquake!" but the doctor said, "No; it's an airquake," an explanation I never heard before nor since till I read it in the bulletin of the Natural History Society.

My third experience of those shocks on solid ground was at Seal Cove about eight years ago, say at 11 o'clock in the evening, when the shock was exactly as the former ones, the night being quiet and dark with very light winds. Again on the 28th of January of this year (1897) at 9 o'clock in the evening we got such a shock under this lighthouse that we thought the tops of our chimneys had gone by the board. Our dogs took to barking and our cattle tried to break loose in the stable. I noted this shock in my journal and told my people that we would hear of an earthquake on the mainland, but when the mail came we found that the earthquake was two days ahead of our tremor. On the evening of February 14, at 9 p. m., we received another shock, but not so violent as that of January.

I have given you my experience of fifty-nine years, and I will now affirm that I strongly believe these sounds are of subterranean origin.

(C) E. W. Suthern, from a letter to Mr. Kain, dated April 15, 1898, at Westport Light, Brier Island, Digby County, N. S.:

I have noticed these sounds many times when I have been out on the Bay of Fundy on fine, calm days in the summer. I spend a good deal of time in this way, shooting porpoises and birds. The sounds heard in this place are like the distant firing of heavy guns. I have heard these sounds on all sides of my boat, and that is what has puzzled me. I have heard them between my boat and the shore when one-half mile off shore, and again I have heard them in the same direction, ten miles off. I have also heard them in a southwesterly direction, and there is no land within 300 miles southwest of here, and I know that the Indians are not shooting porpoises in that direction.

In my opinion these sounds are not the firing of guns; they are heard